ULTRA-LOW FREQUENCY

BAND-PASS FILTER

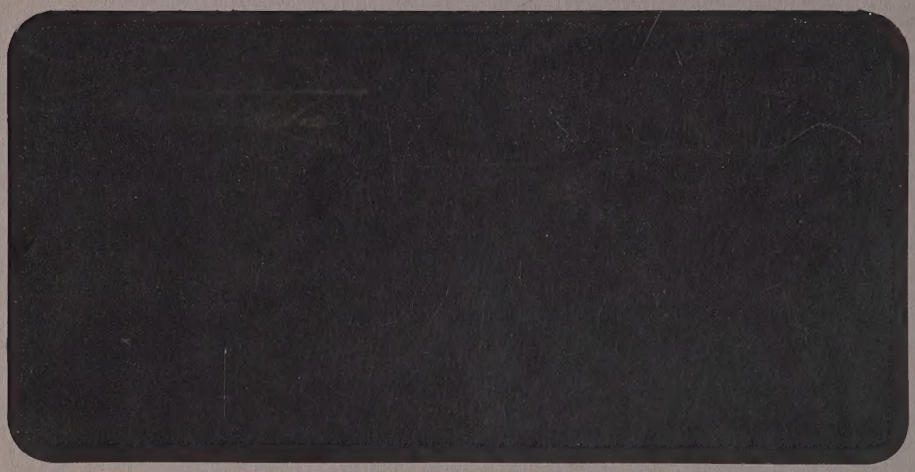
MODELS 330A(R), 330M(R)

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge, Mas

C6-S4-116



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SERIAL NO. 3162

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge, Mass., 02139, U.S.A.

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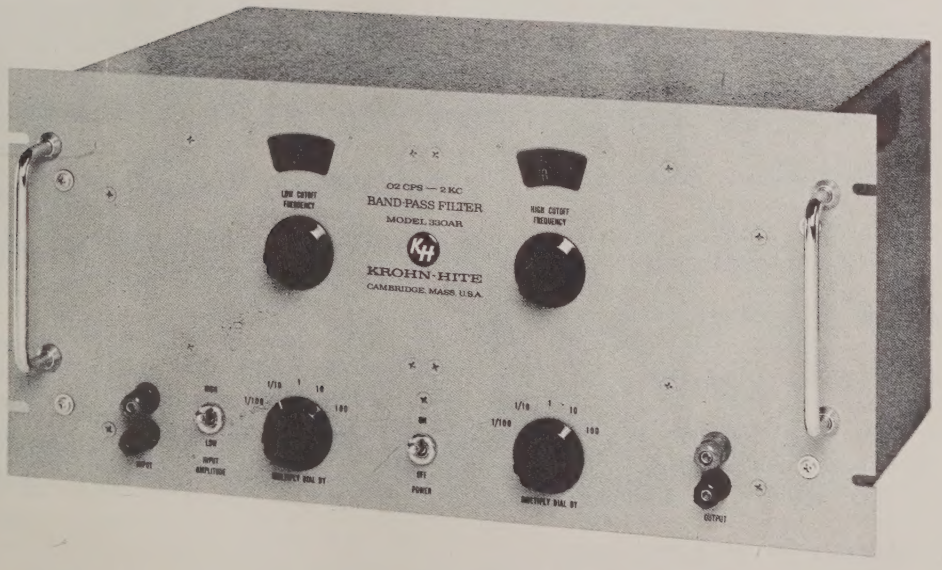
Models 330-A
◀ and 330-M



Models 330-AR
and 330-MR ▶

Figure 1 — Ultra-Low Frequency Band-Pass Filters
Models 330-A, 330-M, 330-AR, 330-MR

1. TECHNICAL SUMMARY

TYPE: Band-Pass.

BAND WIDTH: Continuously variable up to the maximum width covering the entire range from 0.02 cps to 2 kc in the Model 330-A(R) and from 0.2 cps to 20 kc in the Model 330-M(R).

FREQUENCY RANGE: Continuous coverage over the entire frequency range for both high cut-off and low cut-off frequencies independently; frequency range is covered by separate calibrated dials and five-decade band switches; center frequency and width of pass band continuously adjustable within the designated frequency range.

		FREQUENCY (CPS)	
BAND	MULTIPLIER	Model 330-A(R)	Model 330-M(R)
1	1/100	0.02 - 0.20	0.2 - 2.0
2	1/10	0.20 - 2.0	2.0 - 20
3	1	2.0 - 20	20 - 200
4	10	20 - 200	200 - 2,000
5	100	200 - 2,000	2,000 - 20,000

FREQUENCY DIALS: Each dial is engraved, illuminated and individually hand calibrated with a single logarithmic scale reading directly in cycles per second from 1.9 to 21 in the Model 330-A(R) and from 19 to 210 in the Model 330-M(R); dials are 5 inches in diameter with an effective scale length of approximately 9 inches per band giving a total effective scale length of approximately 45 inches for the entire frequency range.

*ACCURACY OF CUT-OFF FREQUENCY CALIBRATION: ±5%.

*INSERTION LOSS: ZERO db ±1 db in pass band.

*ATTENUATION SLOPE: Each side, nominal 24 db per octave with peaking factor to reduce attenuation at the cut-off frequencies.

MAXIMUM ATTENUATION: Greater than 80 db.

INPUT CHARACTERISTICS:

IMPEDANCE: Approximately 22 megohms in parallel with 200 mmfd in the Model 330-A(R); approximately 22 megohms in parallel with 20 mmfd in the Model 330-M(R).

MAXIMUM INPUT AMPLITUDE:
10 volts rms with INPUT AMPLITUDE switch in HIGH position;
1 volt rms with INPUT AMPLITUDE switch in LOW position.

MAXIMUM DC COMPONENT: 400 volts.

1. TECHNICAL SUMMARY (cont'd)

OUTPUT CHARACTERISTICS:

*IMPEDANCE: Approximately 5,000 ohms with INPUT AMPLITUDE switch in HIGH position; 500 ohms with INPUT AMPLITUDE switch in LOW position.

MAXIMUM POWER: 5 volts rms across 5,000 ohms or 5 millwatts in HIGH position of the INPUT AMPLITUDE switch.

*INTERNALLY GENERATED HUM AND NOISE: Less than 1 millivolt with INPUT AMPLITUDE switch in HIGH position; less than 100 microvolts with INPUT AMPLITUDE switch in LOW position.

CONTROLS:

LOW CUT-OFF FREQUENCY dial.
Low cut-off frequency MULTIPLY DIAL BY switch.
HIGH CUT-OFF FREQUENCY dial.
High cut-off frequency MULTIPLY DIAL BY switch.
INPUT AMPLITUDE HIGH-LOW switch.
POWER OFF-ON switch.

TERMINALS: Two multi-purpose binding posts for the INPUT and two for the OUTPUT.

POWER REQUIREMENTS:

105-125 volts, single phase.
50-60 cycles (400 cycle model available on special order).
50 watts.

FUSE PROTECTION: 1 ampere slow-blow.

TUBE COMPLEMENT (furnished with instrument): 8-12AX7, 3-12AU7, 1-12AY7, 1-6AU5-GT, 1-6AX5-GT, 1-0G3/85A2.

FORM: Overall dimensions Model 330-A and Model 330-M: 17" wide, 8" high, 12" deep. Weight: Model 330-A, 37 lbs. net, 42 lbs. shipping; Model 330-M, 29 lbs. net, 34 lbs. shipping. Rack mounting available, overall dimensions Model 330-AR and Model 330-MR: 19" wide, 8 3/4" high, 12" deep. Weight: Model 330-AR, 37 lbs. net, 41 lbs. shipping; Model 330-MR, 30 lbs. net, 34 lbs. shipping.

* Refer to corresponding headings under DETAILED SPECIFICATIONS.

SECTION II - DETAILED SPECIFICATIONS

1. ACCURACY OF CUT-OFF FREQUENCY CALIBRATION.

The high and low cut-off frequencies, as defined below, will be within 5% (±5%) of the corresponding dial reading. KROHN-HITE Electronic Filters are calibrated to conform to each of the following definitions:

(a) Cut-off frequency can be defined as the frequency which is the reciprocal of $2\pi T$ in the filter transfer function. At this frequency the phase shift through either the high pass or the low pass filter section alone is exactly 180 degrees.

(b) Cut-off frequency is also the frequency at which the extension of the straight portion of the filter attenuation slope (24 db per octave) intersects the extension of the pass band gain characteristic. If the attenuation rate should differ from 24 db per octave (see ATTENUATION SLOPE below) this method of determining the cut-off frequency is not valid.

(c) From passive filter terminology the cut-off frequency is the frequency at which the output of the filter is 3 db down from the output at the middle of the pass band.

When checking the cut-off frequency calibration accuracy as defined in (c) above, refer to Figure 3. Cut-off frequency gain is the amount by which the filter output at the cut-off frequency differs from the mid-band or mean frequency output. This gain varies with separation of the cut-off frequencies (see FILTER CHARACTERISTICS) and it is plotted in Figure 3 as a function of the ratio of high to low cut-off frequencies. Cut-off frequency gain approaches minus 3 db for wide separations (curve A of Figure 2) has a maximum of about minus 4.2 db for a factor of four separation (curve C of Figure 2) and goes to zero db when the cut-off frequencies coincide.

2. INSERTION LOSS.

The filter output voltage under open circuit conditions will be within 1 db (±1 db) of the input voltage for all frequencies within the pass band. The pass band, for the purpose of specifying insertion loss, is defined as the frequency spectrum from ten times the low cut-off frequency setting to one tenth of the high cut-off frequency setting. To determine the insertion loss (pass band gain) accurately, the high and low cut-off frequencies must be at least a factor of one hundred apart, and the measuring frequency must be the geometric mean of these frequencies. Note that in all cases Figures 2, 3, 4, 5 and 6 show a reference output level. The reference output level can be readily converted to input level once the pass band gain has been determined exactly for a particular instrument.

3. ATTENUATION SLOPE.

A typical attenuation curve is shown in Figure 4. At the cut-off frequency the slope is approximately 12 db per octave, and at the

12 db point the slope has essentially reached its nominal value of 24 db per octave. The slope of the straight portion of the curve may be slightly less than 24 db per octave at certain frequencies because of cross-coupling effects, and at the extreme ends of the frequency range this slope may exceed 24 db per octave because of the fall-off in internal amplifier gain which adds to the normal attenuation.

4. OUTPUT IMPEDANCE.

The rated output impedance is the source impedance and is also the minimum load that may be connected to the filter. For this value of load the insertion loss will be approximately 6 db. Lower values of load resistance will not damage the instrument but will increase the distortion. Higher values of external load may be used with no sacrifice in performance and correspondingly lower insertion loss. In the case of these instruments there is no requirement that the load impedance match the output impedance.

5. INTERNALLY GENERATED HUM AND NOISE.

This specification is based on the use of Ballantine Model 310 Voltmeter, or equivalent. This measurement is made with the INPUT terminals connected together by a low impedance shorting jumper, no other external signal connections to the instrument and the voltmeter leads shielded.

6. FILTER CHARACTERISTICS.

Several normalized filter characteristics are shown in Figure 2 for different settings of the cut-off frequencies.

Peaking circuits, which are used to sharpen the corners of the pass band characteristic, introduce gain peaks in the pass band approximately one octave above the low cut-off frequency and one octave below the high cut-off frequency. Curves A and B of Figure 2 show gain peaks of about 0.75 db. When the cut-off frequencies are set approximately two octaves apart (a factor of four), the peaks coincide causing a further increase in the gain peak. Curve C of Figure 2 shows a gain peak of about 1.5 db. The improvement in the filter characteristic effected by the corner peaking circuits is shown by the difference between curves A and B of Figure 4.

The typical pass band characteristic for any cut-off frequencies can be plotted from curve C of Figure 4, since the gain at any frequency is the sum of the gains due to both the high and low cut-off filter sections. For example, consider the case mentioned above of high and low cut-off frequency separation of a factor of four. The high cut-off frequency is represented by 1 on the f/f_H

scale, the mean frequency is at 0.5 on this same scale, and the curve shows a gain value of 0.75 db. The low cut-off frequency is represented by 1 on the f_L/f scale, the mean frequency is at 0.5 on this scale and a second gain of 0.75 db is shown. The net gain at the mean frequency is 1.5 db with respect to the normal pass band gain. At the high cut-off frequency there will be a loss of 3 db due to the high cut-off section, represented by 1 on the f/f_H scale, and a gain of 0.3 db from the low cut-off section, shown at 0.25 on the f_L/f scale. Gain at both the high and low cut-off frequencies is minus 2.7 db because the curve is symmetrical about the mean frequency. As many more points as required may be determined in a similar manner.

7. MINIMUM PASS BAND.

Minimum pass band width is obtained by setting the high and low cut-off frequencies equal. In this case, the lower 3 db point is at 0.77 times the cut-off frequency; the upper 3 db point is at 1.30 times the cut-off frequency, and the insertion loss is 6 db. See Figure 5. Crossing over the high and low cut-off frequencies increases the pass band width and at the same time increases the insertion loss.

8. DISTORTION.

Filter distortion is a function of several variables and is difficult to specify exactly. In general, if the filter is operated within its ratings, distortion products introduced by the filter and not present in the INPUT signal will not exceed 0.5% of the OUTPUT signal. In most cases distortion will be considerably less than 0.5%.

9. TRANSIENT RESPONSE.

This term is sometimes used in reference to filters in an attempt to specify performance when impulse voltages are applied to the filter input. Mathematical analysis and laboratory measurements show that for a given input signal (complex wave, square wave, step function, etc.) all filters will produce an output signal which depends only on the transfer function vs. frequency and is not affected in any manner by the electrical composition of the filter (RC,m-derived, etc.). The phase and/or amplitude of the individual input signal frequency components may, however, suffer undue distortion at the output if the filter does not have a smooth transfer characteristic with no pronounced peaks. Distortion of this nature is minimized by the design of KROHN-HITE Filters. These filters represent the optimum practical approach to ideal filter characteristics combined with versatility to give unsurpassed performance.

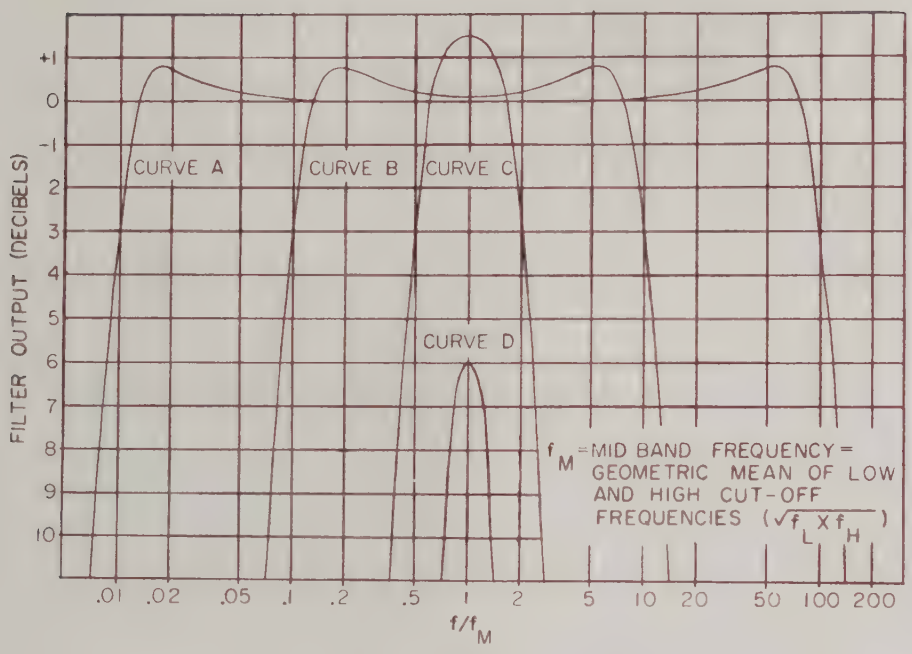


Figure 2 - TYPICAL NORMALIZED PASS BAND CHARACTERISTICS

Curve A

High and low cut-off frequencies separated by a factor of 10,000. Note that the filter gain (insertion loss) through the middle of the pass band is shown as zero db. This is an arbitrary reference level and can vary plus or minus one db from the input signal when there is no load on the filter output.

Curve B

Inter-action of high and low cut-off peaking circuits increases mid-band gain by approximately 0.1 db when the cut-off frequency separation is reduced to a factor of 100.

Curve D

Mid-band gain increased by approximately 1.5 db when high and low cut-off frequency separation is reduced to a factor of 4.

Curve D

Minimum pass band width is obtained by setting the cut-off frequencies equal. Gain at the peak of the pass band is reduced by approximately 6 db. Refer to Figure 5.

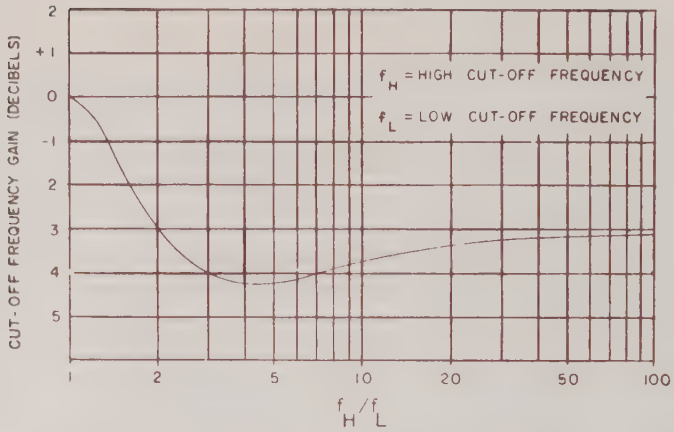


Figure 3 - MODIFIED CUT-OFF FREQUENCY GAIN

Cut-off frequency gain values from this curve must be used in order to check calibration of the filter accurately when high and low cut-off frequency separation is less than a factor of 100. Cut-off frequency gain is the amount by which the filter output at the cut-off frequency differs from the mid-band or mean frequency output. See 1(c) Accuracy of Cut-Off Frequency Calibration.

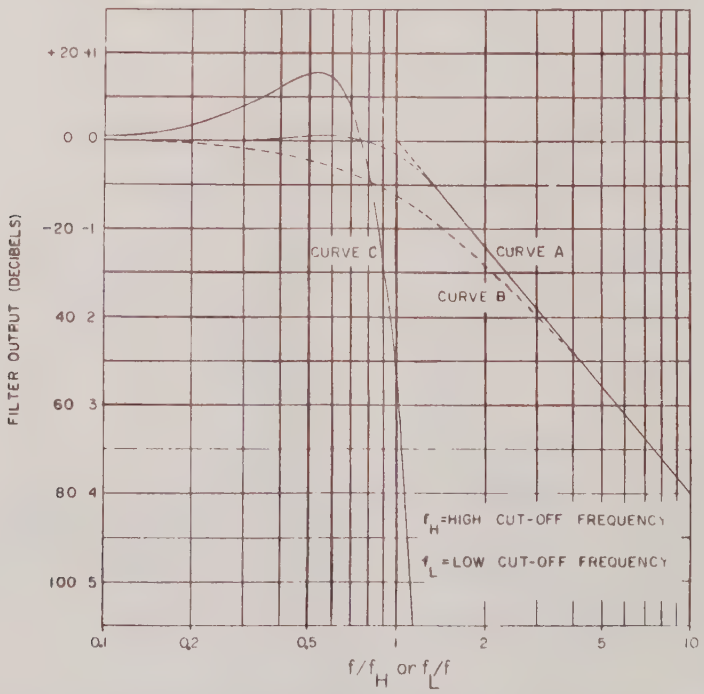
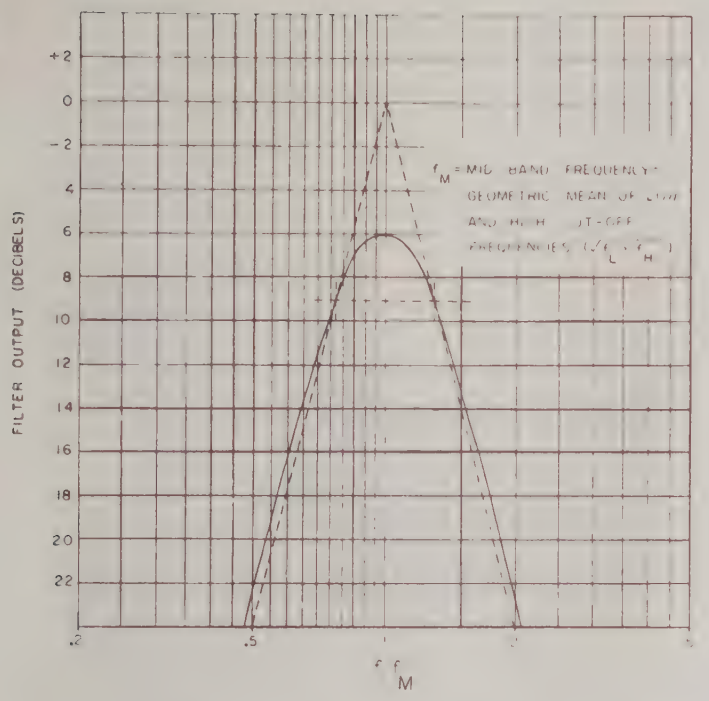


Figure 4 - TYPICAL NORMALIZED ATTENUATION CHARACTERISTICS

Curve A - Attenuation characteristic shown to the minus 80 db level.

Curve B - Attenuation characteristic obtained without corner peaking circuits.

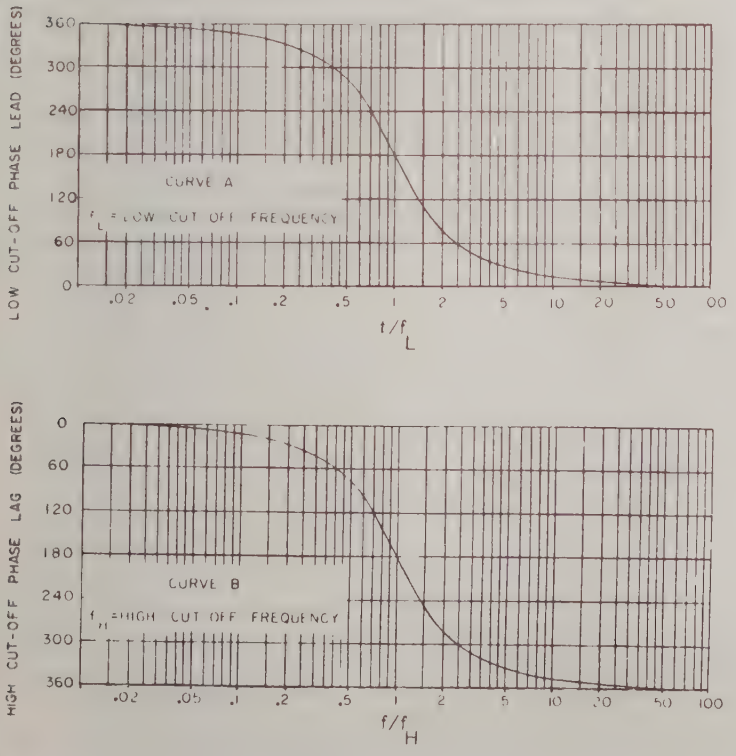
Curve C - Pass Band characteristic near the cut-off frequency (unity) shown on expanded db scale.



Filter pass band characteristic for minimum band-width setting. High and low cut-off frequencies are equal (unity) and insertion loss at the peak of the pass band is 6 db. The 3 db down points, measured from the peak, occur at 0.77 and 1.30 times the cut-off frequency.

Dash lines are extensions of the 24 db per octave slope which intersect the output signal reference level at the cut-off frequency.

Figure 5 - TYPICAL NORMALIZED PASS BAND CHARACTERISTIC - NARROW BAND OPERATION



Phase shift introduced by the low and high cut-off filter sections is shown by Curves A and B respectively where the cut-off frequencies are represented by unity on the normalized frequency scale. Total phase shift through the filter at any frequency is the sum of the phase shifts of the low and high cut-off sections at that frequency. Phase lag is considered to have a negative sign and phase lead a positive sign.

Figure 6 - TYPICAL NORMALIZED PHASE CHARACTERISTICS

The Models 330-A(R) and 330-M(R) ULTRA-LOW FREQUENCY BAND-PASS FILTERS, shown in Figure 1, are adjustable filters whose gain is unity in the pass band and drops outside the pass band at a rate of 24 db per octave. The instruments are completely electronic and easily portable. They operate from an ac source of 105-125 volts, 50-60 cycles per second. An integral power supply furnishes the heater voltages and the regulated dc voltages required for operation. The Models 330-AR and 330-MR are rack mounted units of the Models 330-A and 330-M.

Both the high and low cut-off frequencies are independently adjustable from 0.02 cps to 2 kc in the 330-A(R) and from 0.2 cps to 20 kc in the 330-M(R). This provides maximum flexibility of adjustment of both the band center frequency and the band width. Two identical frequency dials and multiplier switches are used for the cut-off frequencies. Each dial is single scale, illuminated, direct reading, and engraved logarithmically from 1.9 to 21 in the 330-A(R) and from 19 to 210 in the 330-M(R). The associated multiplier switch selects one of the five decade bands. The transfer function of the filter is approximately:

$$\frac{\omega^4 T_1^4}{[(1+2jA\omega T_1-\omega^2 T_1^2)^2]\ [(1+2jA\omega T_2-\omega^2 T_2^2)^2]}$$

where the low cut-off frequency is $1/2\pi T_1$ and the high cut-off frequency is $1/2\pi T_2$. The value of the peaking factor, "A", which is normally unity for filters composed of independent resistance-capacitance sections, is fixed in the Models 330-A(R) and 330-M(R) at approximately 0.6. This value produces less than 1 db peaks in the gain versus frequency plot, but reduces the attenuation at the corner frequencies by approximately 9 db, and permits a band width as narrow as one octave with very little attenuation in the center of the pass band.

Figure 11 shows the essential units of the filter in block diagram form. For more details refer to Schematic Diagram, Figure 15.

The filter section combines a high pass filter and a low pass filter. Each is tuned continuously by a four gang potentiometer assembly and in decade steps by a multiplier switch, which changes the size of the filter capacitors.

The input amplifier serves as a buffer between the input and the first filter. Sufficient amplification is used to overcome the loss in the filters so that the overall attenuation from input to output is approximately zero db in the pass band.

Since capacitance coupling is used at the input to this amplifier, a dc signal component will not disturb the operation of the filter. The output circuit is used as a buffer to isolate the last filter and to provide a low output impedance.

SECTION IV - INSTALLATION AND OPERATION

The Models 330-A(R) and 330-M(R) ULTRA-LOW FREQUENCY BAND-PASS FILTERS are completely checked and then carefully packed for shipment to insure you of an instrument that is ready for operation. The filter is easy to operate and requires no initial warm-up period or adjustment.

There are only five front panel controls in addition to the OFF-ON switch.

The HIGH CUT-OFF FREQUENCY and LOW CUT-OFF FREQUENCY controls select the cut-off frequencies as read on single scale illuminated dials, which are engraved logarithmically and calibrated directly in cycles per second.

The two MULTIPLY DIAL BY switches select the proper multiplying factor for all the five bands, each of which covers a frequency range of 10 to 1 with 5% overlap.

The INPUT AMPLITUDE switch permits selection of filter characteristics which are most suitable for a particular application. In the HIGH position the filter will handle an input signal of at least 10 volts rms without overloading. The output impedance is 5,000 ohms and noise generated within the filter is less than one millivolt. For input signals less than one volt rms, the LOW position of the amplitude switch may be used to obtain 500 ohms output impedance and noise reduction by a factor of 10. Gain in the pass band is unity for both positions of the amplitude switch.

The basic circuit of one of the high cut-off sections of the filter is shown in Figure 7.

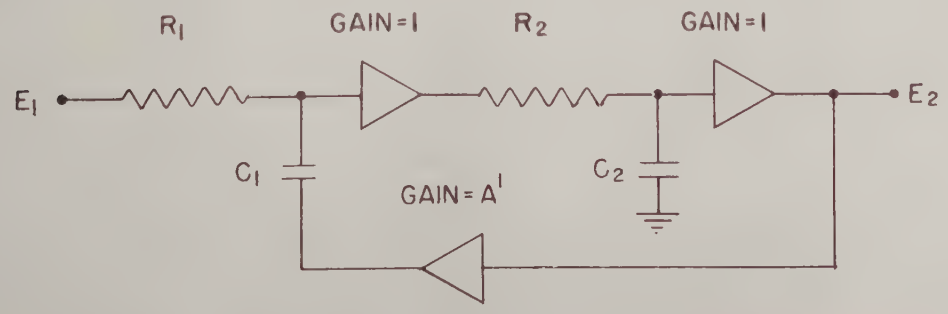


Figure 7 - FUNDAMENTAL CIRCUIT OF ONE HIGH CUT-OFF SECTION

This basic circuit consists of two high cut-off RC sections coupled by unity gain buffer amplifiers. A feedback signal of A^1E_2 is fed back to the first capacitor. If both capacitors are the same, this circuit has a transfer characteristic of:

$$\frac{E_2}{E_1} \quad \frac{1}{j^2\omega^2 (R_1C\ R_2C) + j\omega\ [R_2C + (1-A^1)R_1C] + 1}$$

At the cut-off frequency where

$$j^2\omega^2 R_1C\ R_2C + 1 = 0 \text{ and } \omega_{co} = 1/\sqrt{R_1CR_2C}$$

The gain of the circuit is:

$$G_{co} = \frac{1}{\sqrt{R_2/R_1} + (1-A^1)\sqrt{R_1/R_2}}$$

Thus the G_{co} can be controlled by adjusting "A^1" and the ratio R_2/R_1. The peaking of the response curve for three different values of G_{co} is shown in Figure 8.

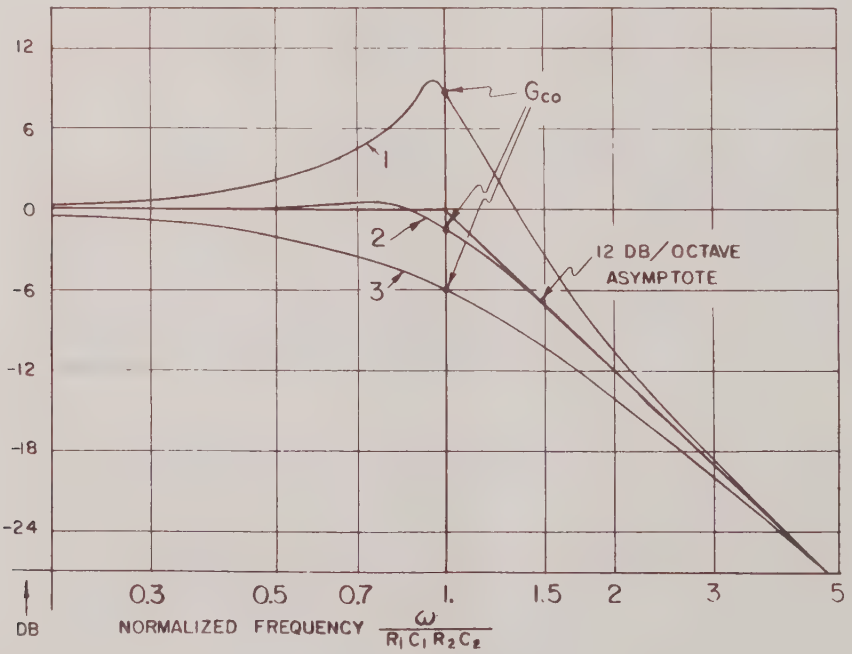


Figure 8 - EFFECT ON CORNER PEAKING CAUSED BY CHANGING G_{co}

Curve 2 is the one used in the filter and is achieved by setting $A^1 = 0.8$ and $R_2/R_1 = 1$ giving a G_{co} for one 12 db per octave section of approximately -.5 db.

The basic circuit of one of the low cut-off sections of the filter is shown in Figure 9.

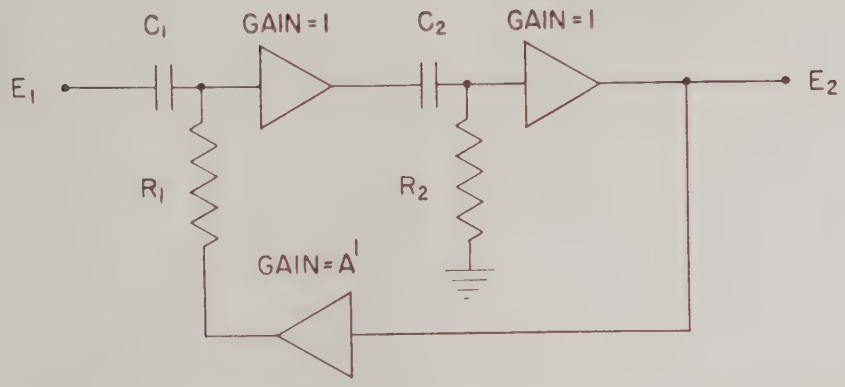


Figure 9 - FUNDAMENTAL CIRCUIT OF ONE LOW CUT-OFF SECTION

The equations for this circuit are:

$$\frac{E_2}{E_1} = \frac{j^2\omega^2 R_1C\ R_2C}{j^2\omega^2 R_1C\ R_2C + j\omega\ [R_1C = (1-A')R_2C] + 1}$$

$$\omega_{co} = 1/\sqrt{R_1C\ R_2C}$$

$$G_{co} = \frac{1}{\sqrt{R_1R_2} + (1-A')\sqrt{R_2/R_1}}$$

The response curves for this circuit come out symmetrical with those on Figure 8 about the $\omega = 1.0$ axis. Again, curve 2 is the one used in the filter and is achieved by setting $A^1 = 0.8$ and $R_1/R_2 = 1$.

The whole filter consists of two high cut-off sections and two low cut-off sections, giving a total peak of about 0.75 db, a total G_{co} of -3 db and a total slope of 24 db per octave at both ends of the pass band. This choice of peaking results in only a small (0.75 db) peak in the curve, but reduces the corner frequency attenuation by 9 db from that obtained by four independent RC sections.

For most applications, the Model 330-A(R) or 330-M(R) is superior to a 24 db filter with independent RC sections, because with the same attenuation outside the pass band, the gain near the corner frequencies is greater. Figure 10 shows the response of these filters (solid curve) and of a similar filter with independent RC sections (dotted curve). The low cut-off frequency is 40 cps, and the high cut-off frequency is 160 cps.

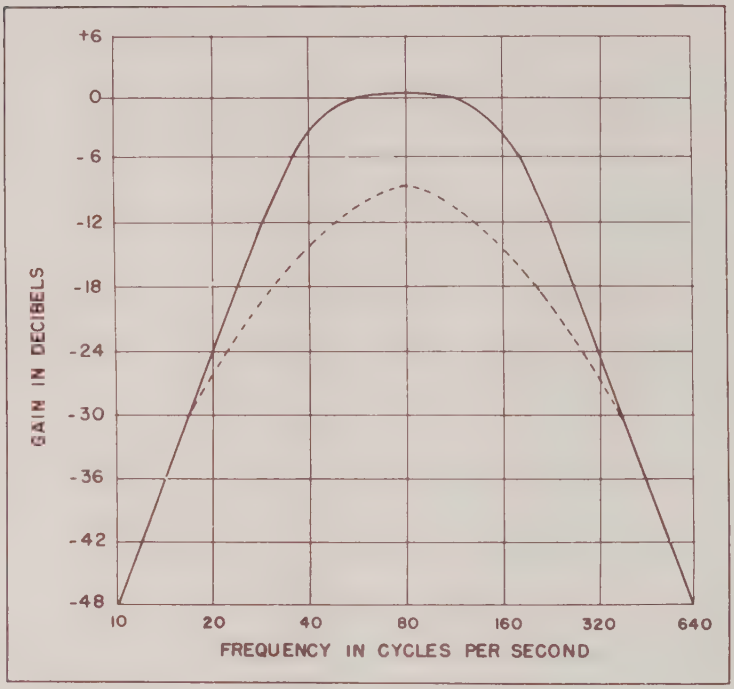


Figure 10 - Solid curve shows the Band-Pass response of the Models 330-A(R) and 330-M(R). Dotted curve is the response of a similar filter with independent RC sections.

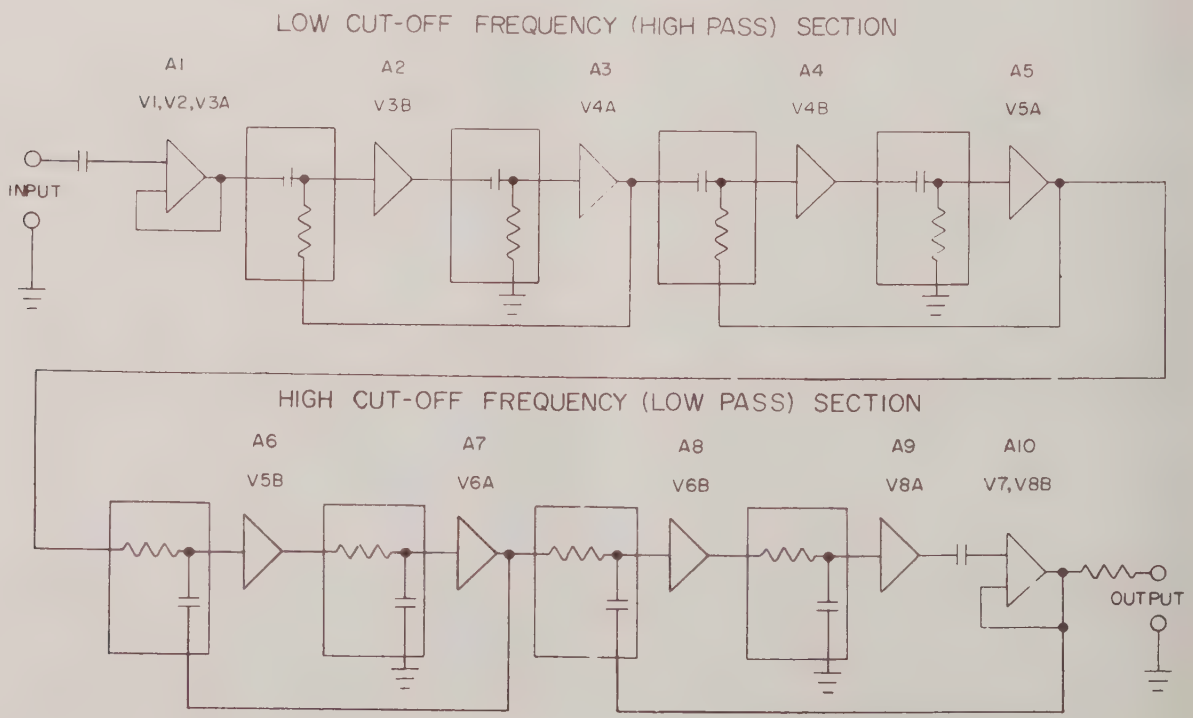


Figure 11 - BLOCK DIAGRAM Models 330-A(R) and 330-M(R)

SECTION V - MAINTENANCE

All the components in the Models 330-A(R) and 330-M(R) are of the highest quality and should have a long trouble-free life since they are operated well below their manufacturer's rating. The following procedure may facilitate locating the source of trouble if the filter does not function properly.

A 1-Ampere (slow-blow) cartridge fuse, located on the rear of the chassis, is used in the primary circuit of the power transformer to protect the power supply components from short circuits. The rating of this fuse was selected for proper protection of the instrument and should be replaced with the same type and rating.

If a fuse failure is detected the following procedure is recommended before replacing the fuse.

(a) Check for a faulty rectifier tube, 6AX5-GT.

(b) Short circuits in 4MFD filter condensers, C54 and C55 used in the unregulated portion of the power supply, can best be detected by connecting an ohmmeter across the terminals directly.

(c) Two electronically regulated power supplies are used in the Models 330-A(R) and 330-M(R) to provide +185 volts and -185 volts with respect to the chassis or ground. One convenient test point for the +185 volts is the cathode of the 6AU5-GT (pin 3). A convenient test point for -185 volts is the negative side of the 4MFD filter condensers, C54 and C55. If a short to ground exists on either regulated voltage buss, check all the tie points connected to it.

(d) The dc resistance of the Power Transformer primary should be 4.5 ohms. A much lower resistance probably indicates a shorted primary.

The likeliest source of failure is the electron tubes since they have an inherently shorter life. Check first to see if all the tubes are inserted securely in the sockets. Although all tubes are securely seated at the plant, it is possible for them to be loosened in shipment. At the same time note if each tube's filament is lit and the voltage reference tube OG3/85A2 is functioning properly as indicated by an amber glow in the tube. If the unit then fails to operate properly and the correct plate and heater supply voltages are present, check the possibility of a faulty tube. Obtain a new 12AU7, 12AX7 and 12AY7 (a 12AX7 may be substituted for a 12AY7 for this test), and then one at a time, substitute the new tube in each position in the filter where it is used. The location of each electron tube is clearly marked on the chassis adjacent to the tube.

In most cases, one of these substitutions will affect a cure. If, however, this approach does not help, a detailed point to point signal tracing analysis should be made.

Apply a 200 cps 10 volt rms sine wave to the INPUT of the filter with the INPUT AMPLITUDE switch in the HIGH position. Set the LOW CUT-OFF FREQUENCY dial to 20 cps and the HIGH CUT-OFF FREQUENCY dial to 2,000 cps. When the filter is operating properly this 200 cps test signal will pass through the filter unchanged and appear on the output with equal amplitude. If the test signal does not appear on the output of the filter it is advisable, at first, to localize the malfunction by determining where the test signal fails to appear within the filter.

Test points in the filter with their correct signal voltages are listed below, in Figure 12, for a 10 volt rms sine wave input. If the test point voltage differs appreciably from the correct voltage, all of the components, wiring, and voltage and resistance readings to ground associated with the tube(s) preceeding the test point should be checked.

LOW CUT-OFF AT 20 CPS - HIGH CUT-OFF AT 2 KC
INPUT AMPLITUDE SWITCH IN "HIGH" POSITION
200 CPS, 10 VOLTS RMS INPUT

TEST POINT		CORRECT SIGNAL VOLTAGE	
TUBE No.	PIN No.	330-A(R)	330-M(R)
V3	8	16.5V	30.5V
V3	3	15.6V	11.5V
V4	8	15.1V	11.3V
V4	3	15.1V	11.1V
V5	3	14.6V	10.9V
V5	8	14.5V	10.8V
V6	3	11.6V	8.4V
V6	8	11.5V	8.3V
V8	3	9.2V	6.7V
V7	2	9.2V	6.7V
V8	8	10V	10V

Figure 12 - TEST POINT VOLTAGES

The range (band) switching capacitors associated with S1 and S2 are specially selected for capacity tolerance. All capacitor values are within ±5% of the specified value, but in order to maintain accurate calibration on all bands, the capacitors on each switch section are so selected that their values are a factor of ten apart within ±2%. The tolerance of all frequency determining capacitors in any one instrument will therefore lie within 2% of the tolerance value rubber-stamped on the 1 UF (200V) capacitors. The dial engraving of the variable resistance elements P1 and P2 is altered to match the overall capacitance tolerance used in each instrument.

Referring to the Schematic Diagram, Figure 15, variable resistances P1-A, B, C and D and P2-A, B, C and D are ganged together and comprise the filter tuning elements. Because high values of resistance which are not obtainable in wire-wound units are required for very low frequency operation, these resistance elements are composition potentiometers, carefully selected, aged, phased and individually hand calibrated in assemblies of four potentiometers each to ensure accurate overall calibration and good tracking over the entire dial. Since these potentiometers are not subjected to appreciable voltages, the only cause of any difficulty should normally be mechanical wear. Our experience with these units over a period of years confirms our original conclusion that, except in rare cases, the potentiometers will have a life equal to or exceeding the normal instrument life.

Should it be necessary for any reason to replace one or more of these potentiometers we strongly recommend that the entire assembly of four potentiometers be replaced with an assembly supplied by the factory complete with its individually calibrated dial.

In an emergency, one potentiometer can be replaced in an assembly and aligned at one point, 6 on the 330-A(R) dial and 60 on the 330-M(R) dial, for example. However, because of differences in potentiometer resistance vs. rotation characteristics, other points on the dial may be in error. The net instrument calibration error will be approximately one-quarter of the potentiometer tracking error at any given point on the dial.

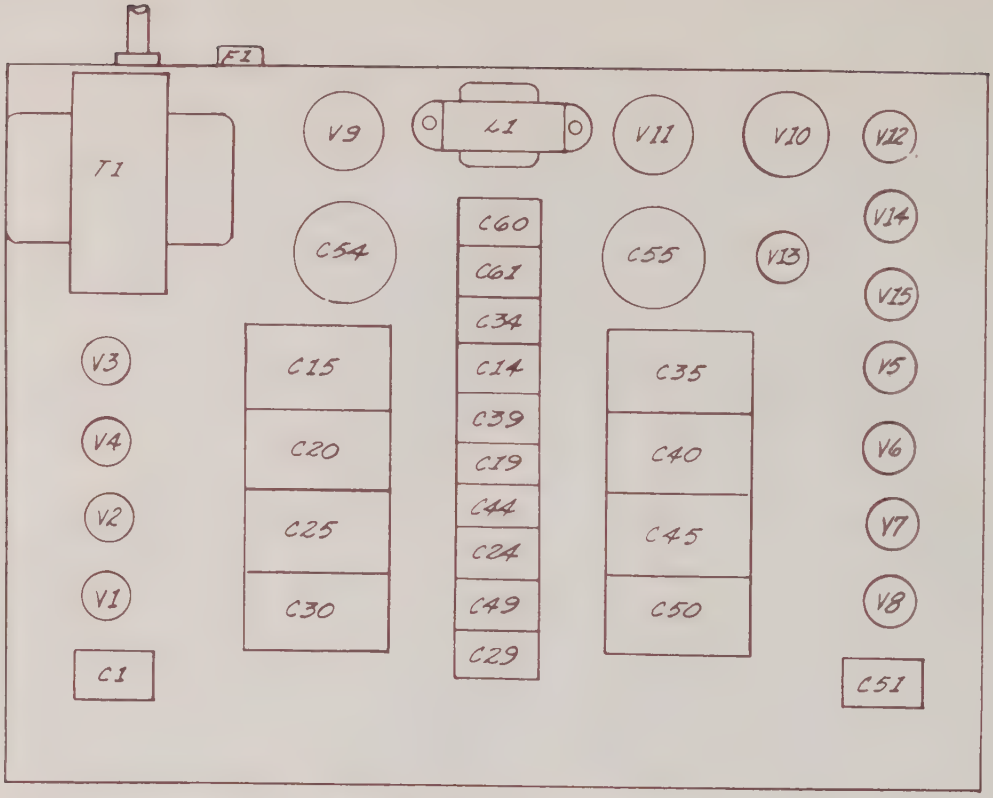


Figure 13 - Model 330-A(R) TOP VIEW OF CHASSIS

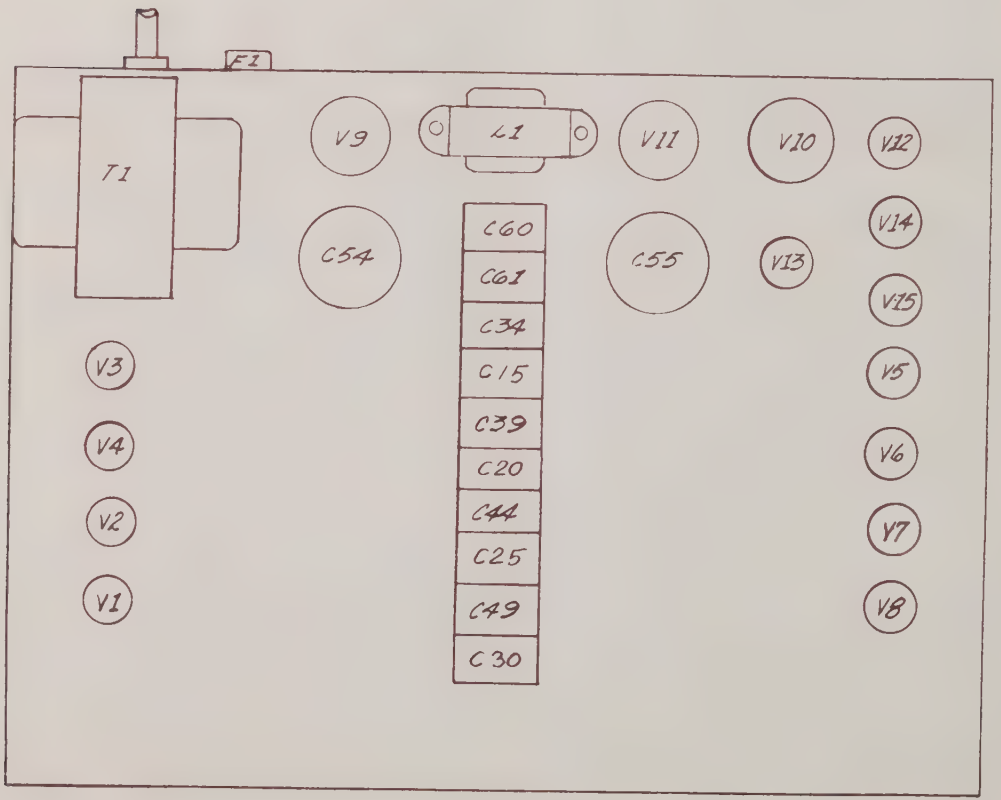


Figure 14 - Model 330-M(R) TOP VIEW OF CHASSIS

SECTION VI - PARTS LIST

This section lists the replaceable parts for Filters, Models 330A(R), and 330M(R).

Listing of replaceable parts is made by a reference symbol (Schematic) as given on schematic diagram, Figure 15.

Description of the Replaceable parts are listed adjacent to the schematic symbol. Manufacturers of replaceable parts are given an abbreviation in the Mfg. column and further identified in the Manufacturer's listing at the end of the parts list. When ordering parts, refer to the Mfg. Part Number column for the manufacturer's part number.

Part differences between models are indicated by letter symbol in the Usable on Code column. When the Usable on Code column is left blank, it indicates that the different part is common to both models. The following letter codes are used to identify the model on which the part is used.

CODE	APPLICABLE MODEL
A	Model 330A(R)
M	Model 330M(R)

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
C1	1 mf, 20%, 400v oil can	C-D	WC4100	A
C1	.5 mf, 20%, 400v paper	C-D	PM4P5	M
C2	.001 mf, 20%, 500v ceramic	SP	40C230A	
C3	470 mmf, 5%, 500v Mica	EL	CM19C471J	A
C3	330 mmf, 5%, 500v, Mica	EL	CM19C331J	M
C3A	14-150 mmf, Trimmer	AR	424	A
C3A	7-100 mmf, Trimmer	AR	423	M
C4	.01 mf, 5%, 400v Paper	SP	67P10354	A
C4	.0047 mf, 5%, 400v, Paper	SP	67P47254	M
C5	390 mmf, 5%, 500v, Mica	EL	CM19C391J	A
C5	51 mmf, 5%, 500v, Mica	EL	CM19C510J	M
C5A	14-150 mmf, Trimmer	AR	424	A
C5A	8-60 mmf, Trimmer	EL	50410	M
C6	.01 mf, 20%, 400v, Paper	SP	67P10304	A
C6	.002 mf, 20%, 500v, Ceramic	SP	19C171	M
C7	.002 mf, 20%, 500v, Ceramic	SP	19C171	
C8	.02 mf, 20%, 500v, Ceramic	SP	36C1821	
C9	24 mmf, 20%, 500v, Dura Mica	EL	DM-15-240	

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
C10	100 mmf, 20%, 500v, Dura Mica	EL	DM-15-101	A
C10	.001 mf, 20%, 500v, Ceramic	SP	40C230A	M
**C11	.001 mf, 100v, Met Paper	K-H	BCM-102	A
C11	49 mmf, 1%, 500v, Mica	EL	CM19C490F	M
C11A	1.5-20 mmf, Trimmer	AR	402	M
**C12	.01 mf, 100v, Met Paper	K-H	BCM-101	A
**C12	950 mmf, 100v, Met Paper	K-H	BCM-102-5	M
**C13	.1 mf, 100v, Met Paper	K-H	BCM-100	A
**C13	.01 mf, 100v, Met Paper	K-H	BCM-101	M
**C14	1 mf, 200v, Met Paper	C-D	MF-111	A
**C14	.1 mf, 100v, Met Paper	K-H	BCM-100	M
**C15	10 mf, 75v, Met Mylar	C-D	MFT104	A
**C15	1 mf, 200v, Met Paper	C-D	MF111	M
**C16	.001 mf, 100v, Met Paper	K-H	BCM-102	A
**C16	110 mmf, 1%, 500v, Mica	EL	CM20C111F	M
**C17	.01 mf, 100v, Met Paper	K-H	BCM-101	A
**C17	.001 mf, 100v, Met Paper	K-H	BCM-102	M
**C18	.1 mf, 100v, Met Paper	K-H	BCM-100	A
**C18	.01 mf, 100v, Met Paper	K-H	BCM-101	M
**C19	1 mf, 200v, Met Paper	C-D	MF111	A
**C19	.1 mf, 100v, Met Paper	K-H	BCM-100	M
**C20	10 mf, 75v, Met Mylar	C-D	MFT104	A
**C20	1 mf, 200v, Met Paper	C-D	MF111	M
**C21	.001 mf, 100v, Met Paper	K-H	BCM-102	A
C21	49 mmf, 1%, 500v, Mica	EL	CM19C490F	M
**C22	.01 mf, 100v, Met Paper	K-H	BCM-101	A
**C22	.001 mf, 100v, Met Paper	K-H	BCM-102	M
**C23	.1 mf, 100v, Met Paper	K-H	BCM-100	A
**C23	.01 mf, 100v, Met Paper	K-H	BCM-101	M
**C24	1 mf, 200v, Met Paper	C-P	MF111	A
**C24	.1 mf, 100v, Met Paper	K-H	BCM-100	M
**C25	10 mf, 75v, Met Mylar	C-D	MFT104	A
**C25	1 mf, 200v, Met Paper	C-D	MF111	M
**C26	.001 mf, 100v, Met Paper	K-H	BCM-102	A

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
**C26	110 mmf, 1%, 500v, Mica	EL	CM20C111F	M
**C27	.01 mf, 100v, Met Paper	K-H	BCM-101	A
**C27	.001 mf, 100v, Met Paper	K-H	BCM-102	M
**C28	.1 mf, 100v, Met Paper	K-H	BCM-100	A
**C28	.01 mf, 100v, Met Paper	K-H	BCM-101	M
**C29	1 mf, 200v, Met Paper	C-D	MF111	
**C29	.1 mf, 100v, Met Paper	K-H	BCM-100	
**C30	10 mf, 75v, Met Mylar	C-D	MFT104	A
**C30	1 mf, 200v, Met Paper	C-D	MF111	M
**C31	.001 mf, 100v, Met Paper	K-H	BCM-102	A
**C31	120 mmf, 1%, 500v, Mica	EL	CM19C121F	M
C31A	.001 mf, 20%, 500v, Ceramic	SP	40C230A	A
**C32	.01 mf, 100v, Met Paper	K-H	BCM-101	A
**C32	.001 mf, 100v, Met Paper	K-H	BCM-102	M
**C33	.1 mf, 100v, Met Paper	K-H	BCM-100	A
**C33	.01 mf, 100v, Met Paper	K-H	BCM-101	M
**C34	1 mf, 200v, Met Paper	C-D	MF111	A
**C34	.1 mf, 100v, Met Paper	K-H	BCM-100	M
C34A	220 mmf, 5%, 500v, Mica	EL	CM19C221J	M
C34B	14-150 mmf, Trimmer	AR	424	M
**C35	10 mf, 75v, Met Mylar	C-D	MFT104	A
**C35	1 mf, 200v, Met Paper	C-D	MF111	M
**C36	.001 mf, 100v, Met Paper	K-H	BCM-102	A
**C36	75 mmf, 1%, 500v, Mica	EL	CM19C750F	M
C36A	100 mmf, 5%, 500v, Mica	EL	CM19C101J	M
**C37	.01 mf, 100v, Met Paper	K-H	BCM-101	A
**C37	980 mmf, 1%, 500v, Mica	K-H	BCM-102-2	M
**C38	.1 mf, 100v, Met Paper	K-H	BCM-100	A
**C38	.01 mf, 100v, Met Paper	K-H	BCM-101	M
**C39	1 mf, 200v, Met Paper	C-D	MF111	A
**C39	.1 mf, 100v, Met Paper	K-H	BCM-100	M
**C40	10 mf, 75v, Met Mylar	C-D	MFT104	A
**C40	1 mf, 200v, Met Paper	C-D	MF111	M
**C41	.001 mf, 100v, Met Paper	K-H	BCM-102	A

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
**C41	100 mmf, 1%, 500v, Mica	EL	CM19C101F	M
C41A	1.5-20 mmf, Trimmer	AR	402	M
**C42	.01 mf, 100v, Met Paper	K-H	BCM-101	A
**C42	.001 mf, 100v, Met Paper	K-H	BCM-102	M
**C43	.1 mf, 100v, Met Paper	K-H	BCM-100	A
**C43	.01 mf, 100v, Met Paper	K-H	BCM-101	M
**C44	1 mf, 200v, Met Paper	C-D	MF111	A
**C44	.1 mf, 100v, Met Paper	K-H	BCM-100	M
**C45	10 mf, 75v, Met Mylar	C-D	MFT104	A
**C45	1 mf, 200v, Met Paper	C-D	MF111	M
**C46	.001 mf, 100v, Met Paper	K-H	BCM-102	A
**C46	68 mmf, 1%, 500v, Mica	EL	CM19C680F	M
C46A	270 mmf, 5%, 500v, Mica	EL	CM19C271J	M
C46B	1.5-20 mmf, Trimmer	AR	402	M
**C47	.01 mf, 100v, Met Paper	K-H	BCM-101	A
**C47	930 mmf, 1%, 500v, Mica	K-H	BCM-102-7	M
**C48	.1 mf, 100v, Met Paper	K-H	BCM-100	A
**C48	.01 mf, 100v, Met Paper	K-H	BCM-101	M
**C49	1 mf, 200v, Met Paper	C-D	MF111	A
**C49	.1 mf, 100v, Met Paper	K-H	BCM-100	M
**C50	10 mf, 75v, Met Mylar	C-D	MFT104	A
**C50	1 mf, 200v, Met Paper	C-D	MF111	M
C51	1 mf, 20%, 400v, Oil can	C-D	WC4100	A
C51	.5 mf, 20%, 400v, Paper	C-D	PM4P5	M
C51A	.001 mf, 20%, 500v, Ceramic	SP	40C230A	A
C51A	.002 mf, 20%, 500v, Ceramic	SP	40C472A	M
C52	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C52A	330 mf, 20%, 500v, Ceramic	SP	40C243A	M
C53	10 mmf, 20%, 500v, Dura Mica	EL	DM-15-100	A
C53	.001 mf, 20%, 500v, Ceramic	SP	40C230A	M
C53A	.0033 mf, 20%, 400v, Paper	SP	67P33204	A
C53A	470 mmf, 20%, 500v, Ceramic	SP	40C209A	M
C54	4 mf, 20%, 330vac, Oil can	AERO	P104J	
C55	4 mf, 20%, 330vac, Oil can	AERO	P104J	

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
C56	.01 mf, 20%, 400v, Paper	SP	67P10304	
C57	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C58	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C59	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C60	1 mf, 20%, 400v, Oil can	C-D	WC4100-3	
C61	1 mf, 20%, 400v, Oil can	C-D	WC4100-3	
C62	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C63	470 mmf, 20%, 500v, Ceramic	SP	40C209A	
C64	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C65	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C66	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C67	.001 mf, 20%, 500v, Ceramic	SP	40C230A	
C68	180 mmf, 20%, 500v, Mica	EL	CM19C181M	M
C68A	8-60 mmf, Trimmer	EL	50410	M
C69	220 mmf, 20%, 500v, Mica	EL	CM19C221M	M
C69A	14-150 mmf, Trimmer	AR	424	M
C70	33 mmf, 10%, 500v, Mica	EL	CM19CC330K	M
F1	Fuse Lamp, Slo-Blo	BU	MDL1	
I1	Bulb	GE	51	
I2	Bulb	GE	51	
L1	7H @ 55 ma, Choke	K-H	C-100-7	
P1-A, B,C,D	Part of KH-330A-1 Assembly		*	A
P1-A, B,C,D	Part of KH-330M-1 Assembly		*	M
P2-A, B,C,D	Part of KH-330A-2 Assembly		*	A
P2-A, B,C,D	Part of KH-330M-2 Assembly		*	M
P3	Hum Adj., 500 ohm, 2w, Pot.	CTS	83-1115-3414	
R1	47 k, 1/2 w, 10%	A-B	EB-4731	A
R1	270 k, 1/2 w, 10%	A-B	EB-2741	M
R2	22 m, 1/2 w, 10%	A-B	EB-2261	
R3	330 k, 1/2 w, 10%	A-B	EB-3341	
R4	510 k, 1/2 w, 5%	A-B	EB-5145	

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
R5	220 k, 1/2 w, 5%	A-B	EB-2245	
R6	10 m, 1/2 w, 10%	A-B	EB-1061	A
R7A	1.8 m, 1/2 w, 5%	A-B	EB-1855	
R7B	3.3 m, 1/2 w, 5%	A-B	EB-3355	
R8	91 k, 1/2 w, 5%	A-B	EB-9135	
R8A	470 ohm, 1/2 w, 5%	A-B	EB-4715	M
R9	2.4 m, 1/2 w, 5%	A-B	EB-2455	A
R9	3.9 m, 1/2 w, 10%	A-B	EB-3955	M
R10	470 ohm, 1/2 w, 10%	A-B	EB-4711	
R11	1.5 k, 1/2 w, 10%	A-B	EB-1521	
R12	1.2 m, 1/2 w, 5%	A-B	EB-1255	
R13	1.8 m, 1/2 w, 5%	A-B	EB-1855	
R14	100 k, 1/2 w, 10%	A-B	EB-1041	
R15	5.1 m, 1/2 w, 5%	A-B	EB-5155	
R16	750 k, 1/2 w, 5%	A-B	EB-7545	
R17	100 k, 1/2 w, 10%	A-B	EB-1041	
R18	27 k, 1/2 w, 10%	A-B	EB-2731	
R19	1.2 m, 1/2 w, 10%	A-B	EB-1251	
R20	4.7 k, 1/2 w, 10%	A-B	EB-4721	A
R20	36 k, 1/2 w, 5%	A-B	EB-3635	M
R20A	47 k, 1/2 w, 10%	A-B	EB-4731	A
R21	47 k, 2 w, 10%	A-B	HB-4731	A
R21	47 k, 2 w, 5%	A-B	HB-4735	M
R22A	Part of KH-330A-1 Assembly		*	A
R22A	Part of KH-330M-1 Assembly		*	M
R22B	Part of KH-330A-1 Assembly		*	A
R22B	Part of KH-330M-1 Assembly		*	M
R23	100 k, 1/2 w, 10%	A-B	EB-1041	
R24A	Part of KH-330A-1 Assembly		*	A
R24A	Part of KH-330M-1 Assembly		*	M
R24B	Part of KH-330A-1 Assembly		*	A
R24B	Part of KH-330M-1 Assembly		*	M
R25	3.3 k, 1/2 w, 10%	A-B	EB-3321	
R26	100 k, 1/2 w, 10%	A-B	EB-1041	

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
R27	470 ohm, 1/2 w, 10%	A-B	EB-4711	
R28A	Part of KH-330A-1 Assembly		*	A
R28A	Part of KH-330M-1 Assembly		*	M
R28B	Part of KH-330A-1 Assembly		*	A
R28B	Part of KH-330M-1 Assembly		*	M
R29	100 k, 1/2 w, 10%	A-B	EB-1041	
R30A	Part of KH-330A-1 Assembly		*	A
R30A	Part of KH-330M-1 Assembly		*	M
R30B	Part of KH-330A-1 Assembly		*	A
R30B	Part of KH-330M-1 Assembly		*	M
R31	18 k, 1/2 w, 5%	A-B	EB-1835	
R32	100 k, 1/2 w, 10%	A-B	EB-1041	
R33A	Part of KH-330A-2 Assembly		*	A
R33A	Part of KH-330M-2 Assembly		*	M
R33B	Part of KH-330A-2 Assembly		*	A
R33B	Part of KH-330M-2 Assembly		*	M
R34	43 k, 1/2 w, 5%	A-B	EB-4335	
R35	180 k, 1/2 w, 10%	A-B	EB-1841	
R36A	Part of KH-330A-2 Assembly		*	A
R36A	Part of KH-330M-2 Assembly		*	M
R36B	Part of KH-330A-2 Assembly		*	A
R36B	Part of KH-330M-2 Assembly		*	M
R36C	5.6 m, 1/2 w, 5%	A-B	EB-5655	A
R36C	1.8 m, 1/2 w, 5%	A-B	EB-1855	M
R37	100 k, 1/2 w, 10%	A-B	EB-1041	
R38A	Part of KH-330A-2 Assembly		*	A
R38A	Part of KH-330M-2 Assembly		*	M
R38B	Part of KH-330A-2 Assembly		*	A
R38B	Part of KH-330M-2 Assembly		*	M
R39	27 k, 1/2 w, 5%	A-B	EB-2735	
R40	220 k, 1/2 w, 10%	A-B	EB-2241	
R41A	Part of KH-330A-2 Assembly		*	A
R41A	Part of KH-330M-2 Assembly		*	M
R41B	Part of KH-330A-2 Assembly		*	A

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
R41B	Part of KH-330M-2 Assembly		*	M
R42	56 k, 1 w, 10%	A-B	GB-5631	
R43	22 m, 1/2 w, 10%	A-B	EB-2261	
R44	680 k, 1/2 w, 5%	A-B	EB-6845	A
R44	330 k, 1/2 w, 5%	A-B	EB-3345	M
R45	1.2 m, 1/2 w, 5%	A-B	EB-1255	A
R45	620 k, 1/2 w, 5%	A-B	EB-6245	M
R46	1.8 m, 1/2 w, 5%	A-B	EB-1855	A
R46	910 k, 1/2 w, 5%	A-B	EB-9145	M
R47	5.1 m, 1/2 w, 5%	A-B	EB-5155	
R48	10 m, 1/2 w, 5%	A-B	EB-1065	
R49	27 k, 2 w, 10%	A-B	HB-2731	A
R49	22 k, 2 w, 10%	A-B	HB-2231	M
R51	5.1 k, 1/2 w, 5%	A-B	EB-5125	
R52	560 ohm, 1/2 w, 5%	A-B	EB-5615	
R53	470 k, 1/2 w, 10%	A-B	EB-4741	
R54	470 ohm, 1/2 w, 10%	A-B	EB-4711	
R55	4.7 k, 1/2 w, 10%	A-B	EB-4721	
R56	1.2 m, 1/2 w, 10%	A-B	EB-1251	
R57	1.8 m, 1/2 w, 10%	A-B	EB-1851	
R58	220 k, 1/2 w, 10%	A-B	EB-2241	
R59	12 k, 1 w, 10%	A-B	GB-1231	
R60	27 k, 2 w, 10%	A-B	HB-2731	
R61	560 k, 1/2 w, 5%	A-B	EB-5645	
R62	560 k, 1/2 w, 5%	A-B	EB-5645	
R63	470 ohm, 1/2 w, 10%	A-B	EB-4711	
R64	1.2 m, 1/2 w, 10%	A-B	EB-1251	
R65	1.8 m, 1/2 w, 10%	A-B	EB-1851	
R66	22 k, 1/2 w, 10%	A-B	EB-2231	
R67	220 k, 1/2 w, 10%	A-B	EB-2241	
R68	100 k, 1/2 w, 10%	A-B	EB-1041	
R69	1.2 m, 1/2 w, 5%	A-B	EB-1255	
R70	1.8 m, 1/2 w, 5%	A-B	EB-1855	

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
R71	220 k, 1/2 w, 5%	A-B	EB-2245	
R72	510 k, 1/2 w, 5%	A-B	EB-5145	
R73	220 k, 1/2 w, 10%	A-B	EB-2241	
R74	1.2 m, 1/2 w, 10%	A-B	EB-1251	
R75	510 k, 1/2 w, 5%	A-B	EB-5145	
R76	510 k, 1/2 w, 5%	A-B	EB-5145	
R77	22 k, 1/2 w, 5%	A-B	EB-2235	M
R78	22 k, 1/2 w, 10%	A-B	EB-2231	M
R79	43 k, 1/2 w, 5%	A-B	EB-4335	M
R80	100 k, 1/2 w, 5%	A-B	EB-1045	A
R80	24 k, 1/2 w, 5%	A-B	EB-2435	M
R80A	82 k, 1/2 w, 5%	A-B	EB-8235	A
R81	12 k, 1/2 w, 5%	A-B	EB-1235	
R82	100 ohm, 1/2 w, 20%	A-B	EB-1012	
R83	100 ohm, 1/2 w, 20%	A-B	EB-1012	
R84	82 k, 1/2 w, 5%	A-B	EB-8235	
R85	470 ohm, 1/2 w, 10%	A-B	EB-4711	
R86	1.1 m, 1/2 w, 5%	A-B	EB-1155	M
S1	Band Selection Switch	K-H	PA-277-060	
S2	Band Selection Switch	K-H	PA-277-060	
S3	Input Amplitude Switch Toggle DPDT	C-H	CH-8373-K7	
S4	Power Switch Toggle SPST	C-H	CH-8280-816	
T1	Power Transformer	K-H	P-100-15	
V1	12AY7 Tube	RCA	12AY7	
V2	12AX7A Tube	RCA	12AX7A	
V3	12AU7 Tube	RCA	12AU7	
V4	12AX7A Tube	RCA	12AX7A	
V5	12AX7A Tube	RCA	12AX7A	
V6	12AX7A Tube	RCA	12AX7A	
V7	12AX7A Tube	RCA	12AX7A	
V8	12AU7 Tube	RCA	12AU7	
V9	6AX5 Tube	RCA	6AX5	
V10	6AU5 Tube	RCA	6AU5	

SECTION VI - PARTS LIST

Schematic Symbol	Description	Mfg.	Mfg Part No.	Usable on Code
V11	OG3 Tube	RCA	OG3	
V12	12AX7A Tube	RCA	12AX7A	
V13	12AU7 Tube	RCA	12AU7	
V14	12AX7A Tube	RCA	12AX7A	
V15	12AX7A Tube	RCA	12AX7A	

MANUFACTURER LISTINGS

Abbreviations	Name	Address
A-B	Allen-Bradley Company	Milwaukee 4, Wisconsin
Aero	Aerovox Corporation	New Bedford, Mass.
AR	Arco Electronics Inc.	New York 13, New York
Buss	Bussman Manufacturing Co.	St. Louis, Missouri
C-D	Cornell-Dublier Elec. Co.	South Plainfield, N.J.
C-H	Cutler-Hammer Inc.	Milwaukee, Wisconsin
CTS	Chicago Telephone Supply Co.	Elkhart, Indiana
EL	Elmenco	Willimantic, Conn.
GE	General Electric Co.	Schenectady, New York
K-H	Krohn-Hite Corp.	Cambridge, Mass.
Sp	Sprague Electric Co.	North Adams, Mass.

When ordering parts from our factory, the following information should be supplied;

Instrument Model Number
Serial Number
Description
Manufacturer
Manufacturer's Part Number

Manufacturer's part no. listed may not agree with part no. found in instrument but parts shown are a direct replacement.

This Parts List applies to all instruments, starting with Serial No. 1716.

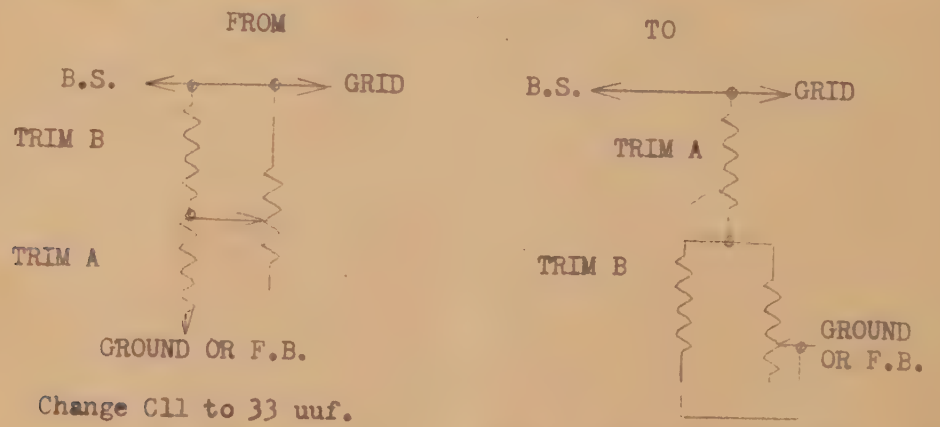
* KH-330A-1, KH-330M-1, KH-330A-2, and KH-330M-2 assemblies are non-repairable items and must be replaced with complete units, obtained from Krohn-Hite Corp.

**These capacitors have a basic tolerance of ±5%. They are selected at the factory to fall in decade steps within 2% of each other. For replacement purposes use ±1% tolerance.

MODEL 330-M(R)

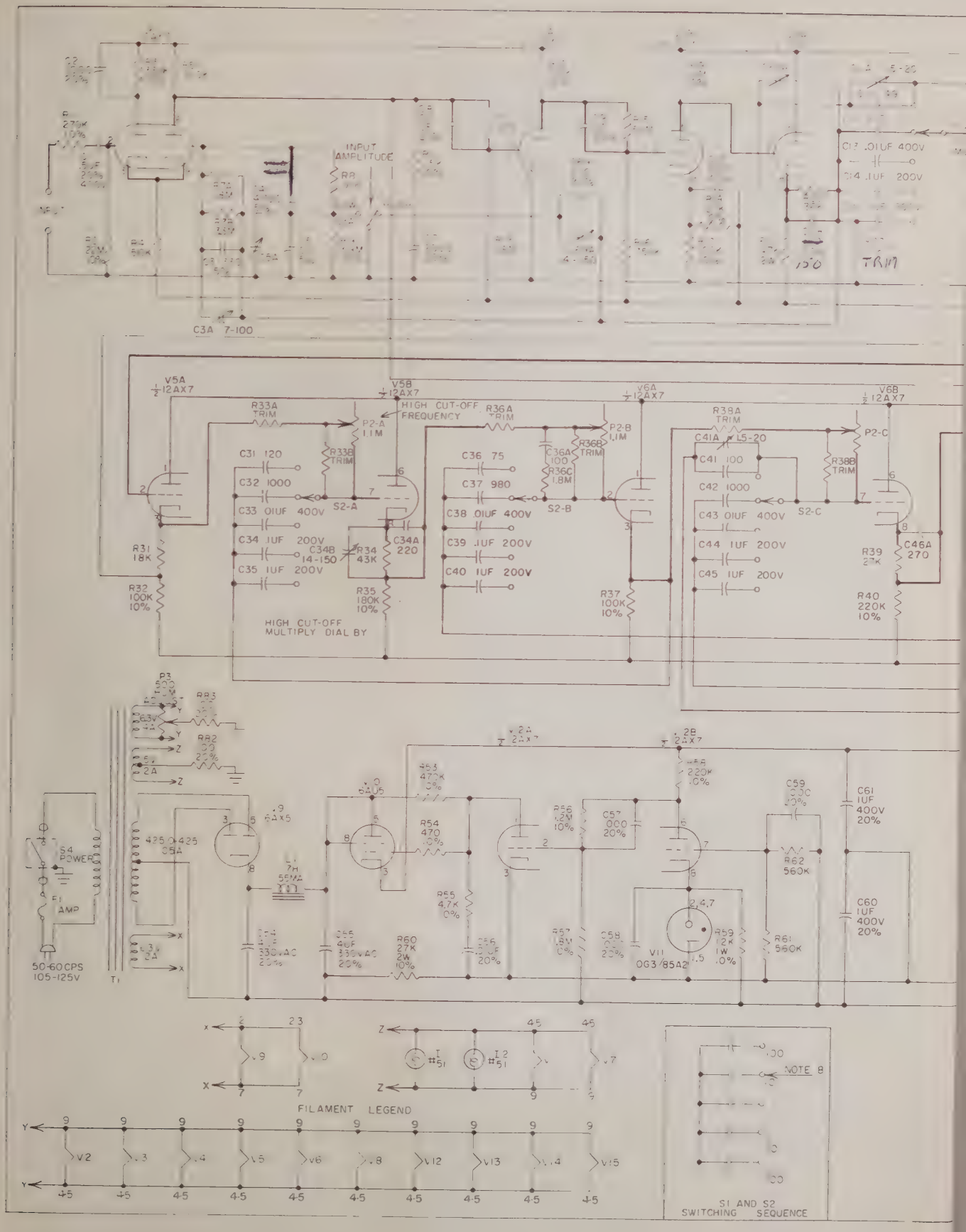
THE FOLLOWING CHANGES,ADDITIONS,& CORRECTIONS ARE NOT REFLECTED ON THE SCHEMATIC (REV. DATE: 9/7/61) AND MAY BE ADDED AT THE DISCRETION OF THE CUSTOMER.

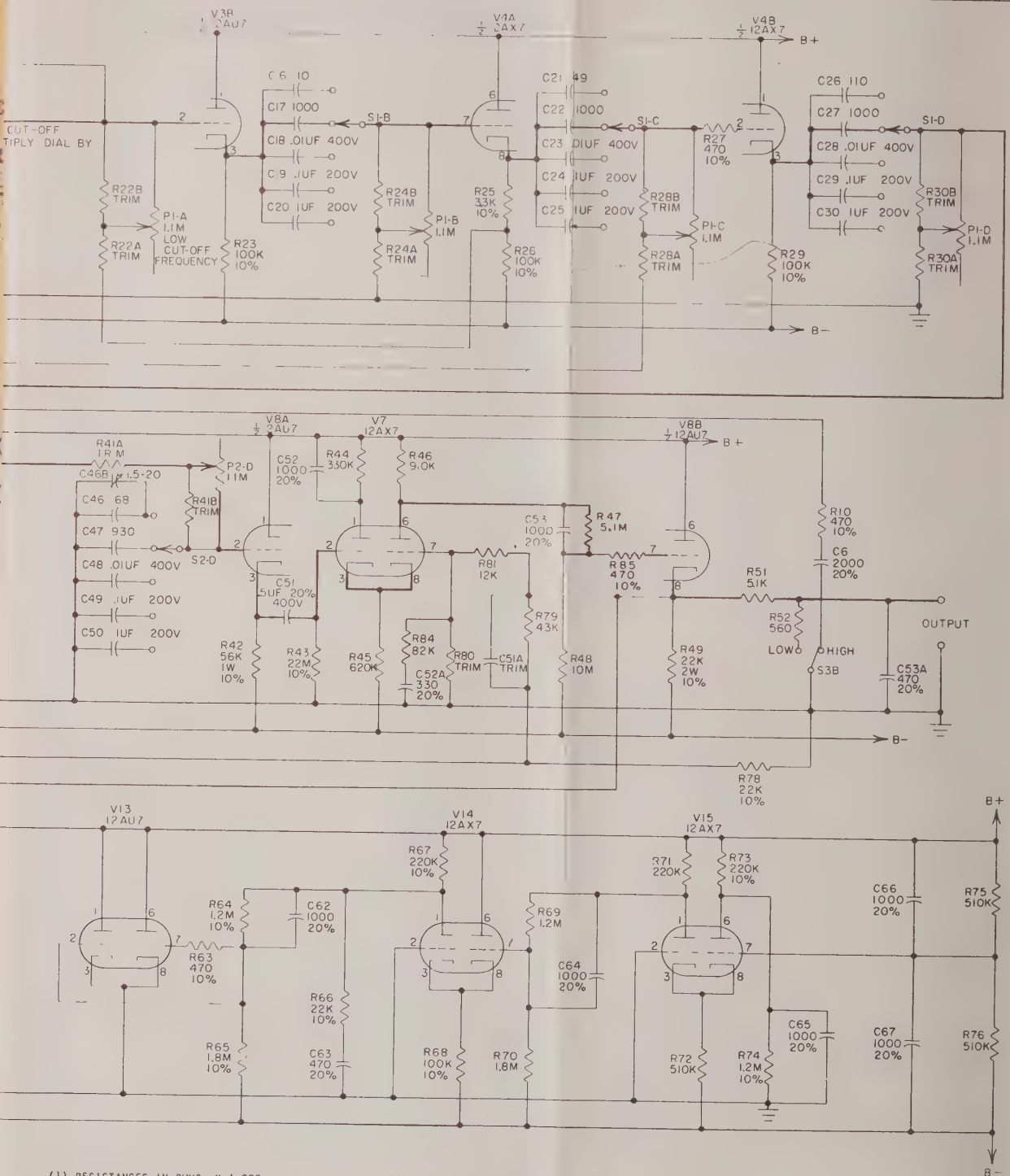
STARTING WITH SERIAL NO.	CHANGES,ADDITIONS,& CORRECTIONS
2499	Add R86 (1.1M 1/2W 5%) in series with C70 (33 uuf 10% 500V) and place these series components in parallel with C11.
2805	Add a dual primary to T1. For 115V/1A: jumper lugs 1&2 and Jumper lugs 3&4. For 230V/.5A jumper lugs 3&2.
2805	Add a rear input and a rear output connector (BNC type).
2847(inc.2845)	Shield the leads connecting the front and rear input connectors.
2861(inc.2858)	Change the wiring of P1 (TUNING ASSEMBLY POTS.):



Change C11 to 33 uuf.

3049(inc.3009)	Change S3 (DPDT,Toggle Switch-INPUT AMPLITUDE SELECTOR) to 4PDT. Connect the middle six lugs together and to ground to act as a shield. Use shielded wire to connect the front and rear output terminals.
3049(inc.3009)	Add P4 (1M linear taper potentiometer) DC LEVEL ADJ. control: 1) Connect P4 between plus high voltage & minus high voltage. 2) Add R87 (1.8M 1/2W 5%) between the center-arm of P4 and pin 7 of V7 (12AX7).
3069 (inc.3064)	1) Shield the rear INPUT terminal & INPUT AMPLITUDE switch. 2) Max. attenuation at 200kc will be greater than 77 db.
3070 (excluding 3076 & 3083)	1) Change R1 (270K 10% 1/2W) to 100K 5% 1/2W. 2) Change the values of these 1% 500V capacitors: a. C31 (120 uuf) to 140 uuf b. C36 (75 uuf) to 50 uuf c. C41 (100 uuf) to 70 uuf d. C46 (68 uuf) to 82 uuf 3) Delete: a. C36A (100 uuf 5% 500V) b. R36C (1.8M 5% 1/2W).


INPUT AMPLITUDE
C3A 7-100
C13 .01UF 400V
C14 .1UF 200V
TRIM
V5A 1/2 12AX7
V5B 1/2 12AX7
V6A 1/2 12AX7
V6B 1/2 12AX7
HIGH CUT-OFF FREQUENCY
R33A TRIM
R36A TRIM
R38A TRIM
P2-A 1.1M
P2-B 1.1M
P2-C
R33B TRIM
R36B TRIM
R36C 1.8M
R38B TRIM
C31 120
C32 1000
C33 .01UF 400V
C34 .1UF 200V
C34B 14-150
C34A 220
C35 .1UF 200V
C36 75
C37 980
C38 .01UF 400V
C39 .1UF 200V
C40 .1UF 200V
C41A 5-20
C41 100
C42 1000
C43 .01UF 400V
C44 .1UF 200V
C45 .1UF 200V
S2-A
S2-B
S2-C
R31 18K
R32 100K 10%
R34 43K
R35 180K 10%
R37 100K 10%
R39 22K
R40 220K 10%
C46A 270
HIGH CUT-OFF MULTIPLY DIAL BY
P3 500
RR3
RR2
S4 POWER
F1 AMP
50-60 CPS 105-125V
T1
425-0-425 85A
5.3V 2A
6.3V 2A
6AX5
6AU6
6AS7
R53 470K 10%
R54 470 10%
R55 4.7K 10%
R56 2.2M 10%
R57 1.8M 10%
R58 220K 10%
R59 12K 1W 10%
R60 27K 2W 10%
R61 560K
R62 560K
C57 .000 20%
C58 .000 20%
C59 .000 20%
C61 .1UF 400V 20%
C60 .1UF 400V 20%
V11 0G3/85A2
7H 55MA
FILAMENT LEGEND
NOTE 8
S1 AND S2 SWITCHING SEQUENCE



(1) RESISTANCES IN OHMS K=1,000 M=MEG=1,000,000.

(2) RESISTORS ±5% 1/2 WATT UNLESS OTHERWISE SPECIFIED.

(3) CAPACITANCES IN UUF UNLESS OTHERWISE SPECIFIED.

(4) CAPACITORS ±10% 500WVDC UNLESS OTHERWISE SPECIFIED.

(5) ALL COMPONENTS LABELLED TRIM ARE FACTORY ADJUSTMENTS.

(6) C5A, C68A, ARE 8-60 UUFD TRIMMER CONDENSERS.

(7) S1 AND S2 SHOWN IN THE X10 POSITION.

(8) ALL CAPACITORS SWITCHED BY S-1 AND S-2 HAVE A BASIC TOLERANCE OF ±5% OF THE VALUE SHOWN. IN ANY ONE INSTRUMENT THESE CAPACITORS ARE SELECTED TO FALL IN DECADE STEPS WITHIN 2%, EXCEPT ON THE HIGHEST FREQUENCY BANDS WHICH ARE COMPENSATED FOR STRAY CAPACITANCES.

ULTRA-LOW FREQUENCY BAND-PASS FILTER

SCALE	FIGURE - 15	DRAWN BY AHW
DATE 8-13-58		REVISED 9-7-61

SCHEMATIC DIAGRAM MODEL 330-M(R)

KROHN-HITE CORPORATION CAMBRIDGE, MASSACHUSETTS	DRAWING NUMBER C-330M-1

All voltage and resistance values measured from the pins of each socket to ground (chasis) with the controls in the following positions:

INPUT AMPLITUDE switch HIGH.
LOW CUT-OFF and HIGH CUT-OFF FREQUENCY dials at 200.
Both MULTIPLY DIAL BY switches at 100.

Voltages measured with instrument operating from 115 volt 60 cps source. DC voltages measured with a VTVM having an input resistance of 11 megohms.

Resistances measured with the power plug removed from the source.

TUBE			PIN NUMBER								
No.	Type		1	2	3	4	5	6	7	8	9
V1	12AY7	V	112	0	3.1	W	W	120	0±.5	2.7	W
		R	670K	22M	540K	100	100	530K	900K	540K	100
V2	12AX7	V	112	-0.8	0	Y	Y	-7.5	-134	-133	Y
		R	440K	950K	0	100	100	1.6M	680K	29K	100
V3	12AU7	V	170	-4.4	5.4	Y	Y	170	-7.5	1.5	Y
		R	340K	190K	110K	100	100	340K	1.6M	31K	100
V4	12AX7	V	170	-25	-24	Y	Y	170	0	1.2	Y
		R	340K	180K	120K	100	100	340K	79K	130K	100
V5	12AX7	V	170	0	1.0	Y	Y	170	1.0	2.4	Y
		R	340K	73K	140K	100	100	340K	220K	240K	100
V6	12AX7	V	170	-34	-32	Y	Y	170	-32	-30	Y
		R	340K	220K	120K	100	100	340K	190K	280K	100
V7	12AX7	V	100	0	0.8	W	W	75	0±.5	1.0	W
		R	660K	22M	620K	100	100	1.2M	13K	660K	100
V8	12AU7	V	170	-46	-35	Y	Y	170	-5.0	0±.5	Y
		R	340K	300K	80K	100	100	340K	4M	12K	100
V9	6AX5	V	--	170	-170	--	-170	--	170	290	--
		R	--	340K	24K	--	24K	--	340K	--	--
V10	6AU5	V	150	170	170	--	290	--	170	290	--
		R	--	340K	340K	--	--	--	350K	--	--
V11	OG3	V	--	-85	--	--	0	--	--	--	--
		R	--	25K	--	--	0	--	--	--	--
V12	12AX7	V	150	-1.9	0	Y	Y	112	-85	-85	Y
		R	--	950K	0	100	100	540K	300K	25K	100
V13	12AU7	V	170	-6.4	0	Y	Y	170	-6.4	0	Y
		R	340K	950K	0	100	100	340K	950K	0	100
V14	12AX7	V	98	0	1.1	Y	Y	170	0±.5	1.1	Y
		R	520K	0	120K	100	100	340K	910K	120K	100
V15	12AX7	V	115	0	1.2	Y	Y	115	0±.5	1.2	Y
		R	510K	0	560K	100	100	420K	360K	560K	100

Figure 16 - Model 330-M(R) TABLE OF VOLTAGE AND RESISTANCE MEASUREMENTS

NOTE: All resistance values in OHMS. K = 1,000 M = 1,000,000.

W = 2.5 volts ac Y = 3.0 volts ac.

Variations of up to ±20% in all readings can be expected.

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge, Mass., 02139, U.S.A.